SERIEs (2011) 2:359–378
DOI 10.1007/s13209-010-0034-3

SERIEs Journal of the Spanish Economic Association

ORIGINAL ARTICLE

# Vertical integration, collusion, and tariffs

**Pedro Mendi · Rafael Moner-Colonques · José J. Sempere-Monerris**

Received: 27 May 2010 / Accepted: 3 November 2010 / Published online: 26 November 2010


**Abstract** This article presents a link between tariff rates and industry structure in a dynamic setting. We examine the role of tariffs on final-goods in a firm's decision to integrate and collude in the presence of competitive imports. It is shown that, under some conditions, the upstream firm has an incentive to engage in vertical integration to introduce profitably a wholesale price above the world input price while not inducing any intermediate or final good imports. Higher tariffs downstream, even with no tariff protection upstream, make this strategy more profitable, and provide a rationale for a positive relationship between tariff protection and vertical integration, which is observed in some industries.

We would like to thank a referee and the co-editor M$^a$ Angeles de Frutos for helpful comments and suggestions. We are also grateful for comments from seminar participants at Universidad de Navarra and Universidad de Burgos, as well as participants in the XXX Simposio de Análisis Económico, 33rd EARIE Conference and XXII Jornadas de Economía Industrial. The authors gratefully acknowledge the financial support from the Spanish Ministerio de Educación y Ciencia, Generalitat Valenciana, and FEDER projects ECO2010-20584, SEJ2007-66581/ECON, SEJ2006-10087, and PROMETEO/2009/068. All errors are our own.

P. Mendi
Department of Business Administration, Universidad de Navarra, Navarra, Spain
e-mail: pmendi@unav.es

R. Moner-Colonques (✉)
Department of Economic Analysis and ERI-CES, Facultad de Economía, Campus dels Tarongers. Avd. dels Tarongers s/n, 46022 Valencia, Spain
e-mail: Rafael.Moner@uv.es

J. J. Sempere-Monerris
Department of Economic Analysis and ERI-CES, University of Valencia and CORE, Valencia, Spain

J. J. Sempere-Monerris
Department of Economic Analysis and ERI-CES, Université catholique de Louvain, Louvain, Belgium

**Keywords** Vertical integration · Monopoly · Tariffs

**JEL Classification** F12 · L12 · L42

## 1 Introduction

One of the fundamental issues in Economic Theory is how to determine the vertical boundaries of the firm. Many theories have been put forward to explain what drives vertical integration, although few of them have focused on how public policies, in particular trade policy, affect firms' incentives to integrate vertically. This paper contributes to the existing literature by analyzing a potential channel by which tariff policy may induce vertical integration. Specifically, we address the question of how changes in the level of tariff protection downstream affect an upstream monopolist's incentives to integrate forward. We make use of a dynamic model that includes a domestic upstream monopolist, a domestic downstream oligopoly and competitive world markets for the upstream and downstream products. The upstream firm may vertically integrate with one or several downstream firms thus gaining the ability to operate in the downstream market. Forward vertical integration occurs for strategic reasons, namely to create a mechanism that allows the upstream firm to discipline non-integrated downstream firms and thus sustain more profitable collusion.[1] However, the organizational costs of the vertical structure, which are increasing in the number of subsidiaries, impose a limit on vertical integration.

We find a non-decreasing relationship between the size of the tariff on imports of the final product and the degree of vertical integration, measured as the number of downstream firms the upstream firm acquires. Essentially, an import tariff imposes a cap on the domestic final good price. Since we find that the optimal collusive price of the final good increases with the number of downstream firms that are part of the vertical structure, the upstream firm's incentives to integrate increase with the tariff. We also find that the vertical structure typically remains inactive in the output market, and makes profits from sales of the input to non-integrated downstream firms at a marked-up price. Hence, despite the existence of vertical integration, our model predicts the prevalence of inter-firm over intra-firm transactions.[2]

Both recent empirical evidence and several cases of industries that have been analyzed in the Economic History literature are consistent with our main findings. In particular, Alfaro et al. (2010) find firm-level evidence on the existence of a positive

[1] For instance, according to Lamoreaux (1985), US Steel was able for some time to control independent manufacturers of finished products by "holding up prices on raw materials and forcing down prices on finished products". The fact that US Steel was a vertically integrated firm meant that it was able to be an active player in the downstream market, while being a potential supplier of raw materials to competitors of its downstream divisions.

[2] The existence of tariffs may affect intra-firm trade flows in vertically integrated industries. The Canadian and Mexican auto plants have extensive intra-firm links with their U.S. counterparts, mediated by large flows of inputs across borders in the framework of the NAFTA agreement. However, in Brazil, which is protected by common external tariffs under the Mercosur Trade Agreement, multinational auto manufacturers tend to set up integrated production facilities that engage in relatively little international trade (see Hanson et al. 2005).

relationship between tariff protection and vertical integration, based on a 2004 cross-section of manufacturing firms from 101 countries. Webb (1980) discusses the case of the early twentieth century German steel industry, whereas Mendi and Veszteg (2009) analyze the case of the late nineteenth century Spanish steel industry. In the latter two cases, an increase in the degree of vertical integration and the prevalence of collusive arrangements were observed following an increase in tariff protection. On a theoretical level, although in a setting different from ours, Ornelas and Turner (2008) focus on the implications of contract incompleteness to show that lower tariffs on an input prompt vertical multinational integration. Their model thus provides an explanation for the observed rise in trade in intermediate goods within multinational firms.

Our contribution is threefold. Firstly, our main result is a contribution to the literature on the effects of trade policy in the presence of vertical relationships. Seminal papers by Spencer and Jones (1991, 1992) have examined how trade policies affect the decision of a potentially vertically integrated foreign firm to supply a domestic intermediate-good market. Since the foreign firm controls the exports of both the intermediate and the final goods, it is able to react strategically to domestic trade policy by altering its export combination, as in Spencer and Jones (1992). We show that trade policies affect trade flows in an unexpected way. Higher tariffs in the final good market foster vertical integration which in turn makes it feasible to implement a collusive mechanism that affects trade flows. With integration, domestic purchases are a substitute for imports of the input, since the upstream domestic firm services the domestic market as a consequence of collusion.

Secondly, our model adds to the literature that studies how vertical integration affects collusion.[3] Specifically, it explains how vertical integration facilitates collusion in the downstream market. The integrated firm is providing the input to the domestic downstream industry and uses its subsidiaries as a credible threat to punish deviations.[4] A contribution closely related to ours is Nocke and White (2007), who have recently put forward the idea that vertical integration might facilitate price agreements among upstream firms. Our paper differs from Nocke and White (2007) in several respects. First, these authors deal with the facilitating effect of vertical integration on collusion upstream, whereas we consider a collusive mechanism implemented in the downstream market. In their paper, both the upstream and downstream industries are domestic oligopolies. In our case there is a world upstream competitive industry which constitutes the alternative supply to the domestic downstream oligopoly. However, the vertical structure is able to service the domestic downstream market, reducing to zero the market share of its upstream competitors, even in the absence of tariff protection upstream. Furthermore, the collusive behavior in Nocke and White (2007) is just determined by the discount factor in the sense that either the monopoly price or

[3] Several factors hinder collusion: asymmetries in costs and capacity, demand elasticity and demand fluctuations, competition in non-price dimensions, barriers to entry, frequency of purchase, and multimarket contact, to mention a few (see Feuerstein 2005, for a survey).

[4] Levenstein and Suslow (2004) provide evidence on over forty contemporary international cartels prosecuted by the United States or European Union in the 1990s. Most of them fixed prices on sophisticated intermediate goods and services and 52% of them have had regional effects. Their industry sample includes chemicals, transportation, steel, graphite and carbon, plastics and paper, and commodities like citric acid and cement.

monopoly output is implemented, if possible. In our case, for a non prohibitive tariff, the tariff is precisely the highest collusive price that can be implemented.

Thirdly, our analysis is also related to the research that studies how tariffs affect collusion. Our model shows that, although the input market is unprotected, higher tariffs in the final good market imply higher collusion in the downstream market because a non-prohibitive tariff imposes an upper limit on the collusive price. The basic reason is that the collusive mechanism only includes the domestic industry at both the upstream and the downstream levels.[5]

This paper is organized as follows: Sect. 2 describes the model. Section 3 analyzes the relationship between collusion and tariff protection, for a given degree of vertical integration. Section 4 discusses the relationship between integration and tariffs. Section 5 presents some numerical examples to illustrate the results from the theoretical model. Finally, Section 6 discusses a number of implications of our analysis and presents some conclusions.

## 2 The model

We consider a domestic economy with two vertically related industries: one producing an intermediate good and another one that transforms the intermediate good into the final good on a one-to-one basis. There is a single upstream firm and $N > 1$ downstream firms that operate in the domestic economy. Domestic firms face perfect competition from foreign producers in both vertically related industries. It is assumed that the domestic intermediate good industry is unprotected while the final good industry is protected by an import tariff, denoted by $T$. It is also assumed that both the upstream firm and the foreign producers of the intermediate good have zero marginal costs. Transformation costs are zero, and thus the downstream firms' marginal costs are just the price at which they purchase the intermediate good. Domestic downstream firms compete in quantities. Domestic demand for the final product is $p = a - bq$ where $a, b$ are positive constants.

In order to conveniently model the implementation of a collusive mechanism, we propose a game with an infinite number of periods.[6] In period $t = 0$, the import tariff $T$ is announced. Given the above assumptions on marginal costs and competition in the final good market, $T$ constitutes the upper bound on the domestic price of the final product. Next and following the announcement of the tariff, the upstream firm chooses the number of downstream firms to integrate with, $M$, giving rise to what we call the vertical structure. Notice that in case of nonintegration, the upstream firm ends up with zero profits. Given $M$, the vertical structure faces organizational costs $\phi(M)$ per

[5] Previous work by Davidson (1984) shows that when tariffs are small the output reallocation derived from cost asymmetry leads to an industry structure that is more conducive to collusion among home and foreign oligopolistic firms. In contrast, Fung (1987) finds that a tariff may hinder collusion in a cartel of international firms when home and foreign firms compete in each other's market. Recently, Bond and Syropoulos (2005) found that there is a non-monotonic relation between tariff levels and the sustainability of collusion.

[6] Collusion arises from dynamic interaction. The ability to collude depends on the relative importance of current profits compared to future profits in the firms' objective function, as reflected by their discount factor. Therefore, a repeated game is a suitable model to deal with these features.

period, with $\phi(0) = 0$ and $\phi' > 0,\ \phi'' > 0$.[7] Beginning in period $t = 1$, the vertical structure and the remaining downstream firms play an infinitely-repeated game with the following stages in every period:

1. The vertical structure posts a collusive profile, which consists of a price for the final product, a wholesale price, $w \geq 0$, and an output level $\alpha > 0$ for each of the $N - M$ non-integrated downstream firms.
2. Each non-integrated downstream firm decides on the amount of input to purchase and whether to acquire it from the upstream monopolist and/or from the foreign competitive industry. Payments for input purchased are realized.
3. Production takes place and firms collect revenues from sales of the final product.

We assume the use of Nash-reversion strategies, first proposed in Friedman (1971), to sustain collusive outcomes. Notice that we have assumed that the vertical structure has full bargaining power, since it is able to make take-it-or-leave-it offers to non-integrated downstream firms. Positive wholesale prices will be used by the vertical structure to extract profits from non-integrated downstream firms in a collusive outcome.[8] A feature of this collusive outcome is that, while the domestic input price is set above the world price, no input is imported despite the absence of tariffs upstream.

## 3 Collusion and tariff protection

As is usual in studying this type of games, we will proceed backwards, analyzing the final stage of the game first. Given the value of the tariff $T$, and once the number of integrated downstream firms, $M$, is determined, the vertical structure will choose the collusive arrangement that maximizes its profits subject to its own and the non-integrated firms' incentive constraints. The vertical structure's problem reads,

$$
\begin{aligned}
&\max_{\substack{p\leq T,\ w\geq 0\\ \alpha\leq \frac{a-p}{b(N-M)}}} \quad p\left[\tfrac{a-p}{b}-(N-M)\alpha\right]+w\alpha(N-M)\\
&\text{subject to}\ \begin{array}{l}(p-w)\alpha \geq (1-\delta)\pi_n^D(p,w,\alpha,N,M)+\delta\pi^C(N)\\ p\left(\tfrac{a-p}{b}-(N-M)\alpha\right)+(N-M)w\alpha\\ \quad\geq (1-\delta)\pi_{vs}^D(w,\alpha,N,M)+\delta M\pi^C(N)\end{array},
\end{aligned}
\tag{1}
$$

where the top constraint is the non-integrated firms' incentive constraint, while the bottom constraint is the vertical structure's incentive constraint. In the constraints, $\pi_i^D(\cdot)$ denotes single-period optimal deviation profits where the subscript $i = n, vs$ stands for non-integrated firms, $n$, or for the vertical structure, $vs$. Also $\pi^C(N)$ denotes $N-$firm symmetric Cournot profits. First note that the vertical structure will

[7] Convex integration costs arise due to agency costs that are increasing with the number of integrated outlets, in a similar way to that described by Chemla (2003). Convex enough integration costs prevent the equilibrium outcome from being the uninteresting case of full monopolization in all cases.

[8] Mendi (2009) discusses the role of input sales as a mechanism to make side payments among vertically-integrated, colluding firms with asymmetric costs.

always adjust the wholesale price to make the non-integrated firms' incentive constraints binding. Indeed, this condition will allow us to pin down the optimal value of the wholesale price. Also note that the $N-$firm symmetric Cournot outcome can always be sustained provided that the tariff exceeds the Cournot price and regardless of the discount factor. We now proceed to discuss in detail the incentive constraints that are part of the vertical structure's problem, in order to obtain specific expressions for the optimal deviation profits.

*Non-Integrated Firms' Incentive Constraint*

In the collusive outcome, given $p$ and $w$, each non-integrated firm produces a quantity $\alpha$. The vertical structure, which includes $M$ integrated downstream firms, produces $\frac{a-p}{b} - (N-M)\alpha$, yielding an output price $p$. Every non-integrated downstream firm thus faces the following incentive constraint:

$$(p-w)\,\alpha \geq (1-\delta)\pi_n^D(p, w, \alpha, N, M) + \delta\pi^C(N), \tag{2}$$

where the LHS of the inequality are the per period profits if the non-integrated downstream firm agrees with the collusive mechanism proposed. The RHS are per-period profits when it deviates. It consists of $\pi_n^D(p, w, \alpha, N, M, )$, which are optimal deviation profits, plus the corresponding Cournot profits after reversion to the Nash equilibrium outcome.

A non-integrated downstream firm may deviate in two different ways. The first one is prior to purchasing the input, implying the rejection of the terms offered by the vertical structure. The second one is in the production stage implying that the non-integrated firm procures $\alpha$ units of the input from the upstream firm at price $w > 0$ and then purchases some additional units in the world market at zero price. These additional input purchases remain unobserved by the vertical structure and to the rest of the non-integrated firms. We show in Appendix 1 that the deviation occurs in the production stage. Intuitively, secretly expanding output shuns the instantaneous retaliation by the vertical structure. This allows us to write deviation output and profits as

$$q_n^D(p, w, \alpha, N, M) = \frac{p+b\alpha}{2b};\ \pi_n^D(p, w, \alpha, N, M) = b\left(q_n^D\right)^2 - w\alpha. \tag{3}$$

Substituting (3) into (2), and using the fact that non-integrated firms' incentive constraints will always bind, we get:

$$w\alpha = \frac{1}{\delta}\left[p\alpha - (1-\delta)\frac{(p+b\alpha)^2}{4b} - \delta\pi^C(N)\right], \tag{4}$$

which allows us to write the vertical structure's objective function as:

$$\pi_{vs}(p, \alpha, N, M) = p\frac{a-p}{b} - (N-M)\frac{1-\delta}{\delta}\frac{(p-b\alpha)^2}{4b}. \tag{5}$$

*The Vertical Structure's Incentive Constraint*

Deviation by the vertical structure implies expanding its output once it has collected revenues, if any, from sales of the input to the non-integrated downstream firms. Its incentive constraint is thus given by,

$$p\left(\frac{a-p}{b}-(N-M)\alpha\right)+(N-M)w\alpha \geq (1-\delta)\pi_{vs}^{D}(w,\alpha,N,M)+\delta M\pi^{C}(N), \tag{6}$$

where the LHS is revenues from output sales plus input sales to non-integrated firms. Recall that in the collusive arrangement, each of the $(N-M)$ non-integrated firms produces output $\alpha$. The vertical structure's deviation profits are

$$\pi_{vs}^{D}(w,\alpha,N,M)=\frac{(a-b(N-M)\alpha)^{2}}{4b}+(N-M)w\alpha. \tag{7}$$

They consist of the profits from selling output in the final market plus the revenues from the sale of its input since the vertical structure does collect them in case it deviates from the collusive outcome. With this expression in hand, and using the fact that the non-integrated downstream firms' incentive constraints will always bind, we may rewrite the vertical structure's constraint as:

$$p\frac{a-p}{b}\geq\frac{1-\delta}{4b}\left[(a-b(N-M)\alpha)^{2}+(N-M)(p+b\alpha)^{2}\right]+\delta N\pi^{C}(N). \tag{8}$$

There are two cases that arise from the examination of this constraint, depending on whether it is binding or not. As will be seen below, the vertical structure's incentive constraint will be binding for low realizations of the discount factor.

## 3.1 Optimal collusive outcome with a prohibitive tariff

We initially assume the existence of a prohibitive tariff, i.e. a tariff that would allow downstream producers to set a price equal to the monopoly price without attracting any imports of the final good, $T \geq p^{m}$. This guarantees that the vertical structure's pricing strategy is not constrained by the presence of the tariff. The optimal price is given by the solution to the following problem:

$$\begin{aligned}&\max_{\substack{p\leq T\\ \alpha\leq\frac{a-p}{b(N-M)}}}\quad p\tfrac{a-p}{b}-(N-M)\tfrac{1-\delta}{\delta}\tfrac{(p-b\alpha)^{2}}{4b}\\ &\text{subject to } p\tfrac{a-p}{b}\geq\tfrac{1-\delta}{4b}\left[(a-b(N-M)\alpha)^{2}+(N-M)(p+b\alpha)^{2}\right]+\delta N\pi^{C}(N)\end{aligned} \tag{9}$$

and, of course, the constraint $p \leq T$ will be non-binding.

Consider first the case where the vertical structure's incentive constraint is non-binding. There are two possibilities: either $\alpha=\frac{a-p}{b(N-M)}$, in which case the vertical structure does not produce, or $\alpha<\frac{a-p}{b(N-M)}$. It follows from the first-order conditions of the vertical structure's problem that the vertical structure finds it optimal to let non-integrated outlets produce the whole output, at least whenever the output price is high enough. This is because the vertical structure's profits are increasing in $\alpha$ if $\alpha \leq \frac{p}{b}$. Thus, for prices $p \geq \frac{a}{N-M+1}$, it follows that $\alpha = \frac{a-p}{b(N-M)}$ , so that the vertical structure is inactive in the output market and lets non-integrated firms produce the whole output. If this is the case, then the optimal price is

$$\widetilde{p}(\delta, N, M) = a\frac{(N-M+1)+\delta(N-M-1)}{(N-M+1)^2-\delta(N-M-1)^2}. \tag{10}$$

It is worth commenting that $\widetilde{p}(\delta, N, M)$ is an increasing function of $M$ and a decreasing function of $N$ for all $0 < \delta < 1$. It is also an increasing function of $\delta$ for all $0 < M < N-1$ and ranges from $\widetilde{p}(\delta = 0, N, M) = \frac{a}{N-M+1}$ to $\widetilde{p}(\delta = 1, N, M) = p^m$.

An interesting special case is when $M = N-1$ since $\widetilde{p} = p^m$. Thus, when the vertical structure incorporates all the downstream firms except one, the optimal outcome in the presence of a prohibitive tariff would be that the non-integrated firm produces the monopoly output, giving rise to the monopoly price. However, whenever $M < N-1$, the optimal price is strictly below $p^m$ for $\delta < 1$. This contrasts with the collusive arrangement in a symmetric $N$-firm oligopoly,[9] where the monopoly price is sustainable for some values of $\delta < 1$.

There are two interesting implications from the vertical structure's inaction in the output market. The first one is that the wholesale price has to be positive. Sales of the input at a marked-up price are the mechanism that the vertical structure uses to implement side payments that compensate for its inaction in the output market.[10] The second is that the upstream firm sells the input to non-integrated firms and hence intra-firm flows do not necessarily increase, although inter-firm trade in the input will be affected. This result contradicts the classic observation that vertical integration will increase intra-firm flows, that is, trade among subsidiaries at different stages.

Consider now the case corresponding to low realizations of the discount factor where the vertical structure's incentive constraint binds. The incentive constraint together with the first-order conditions of the vertical structure's problem determine the optimal values of $p$ and $\alpha$. Essentially, the vertical structure will set the price that yields the highest profits conditional on the fulfilment of its incentive constraint. It will first select $\alpha$ such that its incentive constraint is satisfied and for that value of $\alpha$ it will then set the price that maximizes its profits.[11] There are again two possibilities: that the vertical structure produces in equilibrium and that it does not. The latter case occurs when the discount factor is low enough. Appendix 2

[9] The result that the optimal collusive price is typically below the monopoly price, is consistent with empirical evidence in a number of industries as reported in Levenstein and Suslow (2006).

[10] This result is in line with that presented in Mendi (2009), in the particular case of a symmetric-cost downstream duopoly.

[11] There is no closed-form solution for these variables, as they enter in a quadratic way in the constraint, as well as in the expression that results from combining the first-order conditions of the problem.

provides details on the calculation of the solution for low values of the discount factor.

### 3.2 Optimal collusive outcome with a non-prohibitive tariff

Let us now analyze the vertical structure's problem in the presence of a non-prohibitive tariff, i.e. $T < p^m$. Let $\widehat{p} = \min\{\widetilde{p}, T\}$ be the output price under the collusive arrangement, where $\widetilde{p}$ is the optimal price that was calculated in the previous subsection. The industry output that sustains the price $\hat{p}$ in the final product market is therefore $\frac{a-\hat{p}}{b}$. The next result establishes how changes in the exogeneous tariff affect the collusive outcome. In order to simplify the exposition, all proofs will be relegated to Appendix 3.

**Proposition 1** *There is a direct relationship between the tariff level and the discount factor up to which the optimal collusive outcome is not modified. Furthermore, the greater the number of integrated firms the smaller the set of discount factor values for which the optimal collusive outcome is not disciplined by the tariff.*

If $\widetilde{p} > T$, then the tariff imposes an upper bound on the pricing behavior of the vertical structure. For instance, we argued in the previous subsection that if $M = N - 1$, then the optimal price is $p^m$, for a high enough value of the discount factor. Hence, the introduction of a non-prohibitive tariff creates a binding constraint on the vertical structure's behavior. Moreover, with a non-prohibitive tariff and $M = N - 1$, the vertical structure finds it optimal to produce some output under the collusive arrangement. To generalize, let $\underset{\sim}{\widetilde{\delta}}(N, M, T)$ be the value of the discount factor such that $\widetilde{p}(\delta, N, M) = T$. For values of the discount factor greater than this threshold, the final good price is equal to the tariff. Since the optimal price $\widetilde{p}$ is a non-decreasing function of the number of integrated downstream firms and non-decreasing in the discount factor, $\underset{\sim}{\widetilde{\delta}}(N, M, T)$ is non-increasing in the number of integrated firms $M$. Thus, the existence of a non-prohibitive tariff might curb the vertical structure's profits. This effective constraint is more likely to arise the greater the number of downstream firms integrated in the vertical structure. This is what yields the relationship between vertical integration, collusion and tariffs. We present the basic result of the relationship between tariff protection and the vertical structure's choice of final good prices. The next section explores how this modifies the vertical structure's profit function, defined in terms of the number of integrated outlets.

## 4 Integration and tariffs

In this section, we analyze the upstream firm's choice of the number of firms to acquire in the initial period of the game and how this choice is influenced by the tariff level in the downstream industry. The upstream firm, when choosing the number of downstream firms to acquire, will compare gross profits with integration costs, which are convex in the number of integrated outlets. We first study the vertical structure's decision in the presence of a prohibitive tariff, and then analyze how a non-prohibitive tariff influences its choice.

### 4.1 Optimal integration with a prohibitive tariff

The analysis in the previous section allows us to construct the reduced-form gross (i.e. excluding integration costs) profit function of the vertical structure, $\pi_{vs}(M, N, T, \delta)$. This function is non-decreasing in $M$, $T$, and $\delta$. Obviously, for $M = N$ the gross profit equals the monopoly profit for every given value of the tariff, regardless of the value of the discount factor, i.e. $min\left\{\frac{T(a-T)}{b}, \frac{a^2}{4b}\right\}$. Additionally, for any $M < N$, when the discount factor approaches one, the vertical structure is able to reduce non-integrated firms' profits to the Cournot level.

The vertical structure compares these gross profits with integration costs $\phi(M)$. Recall that $\phi(0) = 0$ and $\phi' > 0, \phi'' > 0$. With the gross profit function at hand, the upstream firm's decision in the initial period of the game is how many downstream firms to acquire. Thus, the optimal number of outlets is determined by:

$$M^* = \underset{M \in \{0,\ldots,N\}}{\arg\max}\ \pi_{vs}(M, N, T, \delta) - \phi(M), \tag{11}$$

taking into account that $M^*$ must be an integer. The functional form of $\phi$ will determine the number of outlets that are integrated. Convexity of this function makes the upstream firm compare the benefit of integration with the increasing integration costs of running more outlets. Since gross profits are increasing with the number of integrated downstream firms, if the $\phi$ function is convex enough, the solution will be interior, i.e. $M^* < N$. The optimal $M^*$ is a maximum as long as the marginal gross profits vary with the number of outlets by less than the increase in marginal integration costs. Another particular feature is that gross profits are non-decreasing in the discount factor. Consider the case where the non-integrated firms produce the whole output. Then the vertical structure profits are the industry profits minus the profits left to non-integrated firms. Sustainable industry profits are always increasing with the discount factor. Additionally, non-integrated firms' profits are lower since their incentive constraint is binding so they get the deviating profits which are decreasing in $\delta$. This explains the positive relationship between $M^*$ and $\delta$.

### 4.2 Optimal integration with a non-prohibitive tariff

Finally we establish a link between tariff rates and the degree of vertical integration in an industry. As already noted, the effect of a tariff on imports of the final product is to set an upper bound on the sustainable domestic price for the final good. Consequently, the maximum domestic price is merely the tariff. The level of the tariff affects the upstream firm's decision to integrate forward in the following way. If the tariff is sufficiently low, so is the maximum sustainable price in the domestic market, and the upstream firm will have little or no incentive to integrate forward, since it would not be able to make enough profits that compensate for the integration costs. For higher values of the tariff rate, the upstream firm may choose to integrate forward, but not to service non-integrated firms. If the tariff rate is high enough, the upstream firm chooses to integrate forward, and service non-integrated firms. The reason why there is a range of values of the tariff rate that induces the upstream firm to integrate forward, but not to sell the input to non-integrated firms, is that the vertical structure would introduce a wholesale price too low to induce acceptance by non-integrated firms. For this range of values of the tariff rate, the vertical structure is best off letting its outlets behave like any other non-integrated firm.

**Proposition 2** *The equilibrium number of acquired downstream firms is non-decreasing with the tariff level $T$, for $T \in (p^C, p^m)$, and for sufficiently high realizations of the discount factor.*

This proposition establishes a non-decreasing relationship between tariff protection and vertical integration, given that the realization of the discount factor is high enough. The optimal price increases with the number of integrated outlets and is non-decreasing with the discount factor. This means that the higher $M$, the larger the set of realizations of the discount factor for which a given non-prohibitive tariff $T$ is binding. Thus, increasing $T$ means relaxing the constraint imposed on the vertical structure's pricing behavior over a range of values of the discount factor that is increasing with $M$. Whenever the tariff constrains the vertical structure's pricing strategy, a tariff raise benefits the vertical structure more the greater the number of integrated firms. The reason is that the vertical structure can set a higher price in a wider interval of $\delta$ either because the optimal price is charged or because the constrained price is now at a higher tariff level. In other words, the marginal gross profits of the vertical structure with respect to the integrated outlets is increasing with the tariff level. Since integration costs are not a function of the tariff, the equilibrium condition for $M$ is now satisfied for a higher $M$. Therefore this complementarity between tariffs and the number of integrated outlets is the driving force in explaining why the optimal number of integrated outlets increases with the tariff level. Finally, for lower values of the discount factor, since there is no closed-form expression for the pricing function, the relationship cannot be proved, although in the numerical examples that follow there is always a positive relationship between tariffs and integration.

## 5 Numerical examples

We shall use a set of numerical examples to illustrate the previous discussion on the optimal solution. In all cases, consider $a = 50$, $b = 1$ and $N = 4$. With these parameters, $p^m = 25$, and $\pi^C(N) = 100$. All charts show the cases of vertical integration with $M = 1, 2,$ and 3. Integration costs are $\phi(M) = 40M^2$.

### 5.1 Wholesale and final product prices, prohibitive tariff

The first set of results presents optimal wholesale and final product prices for the extreme case of a prohibitive tariff downstream. Figures 1 and 2 plot the posted market price and wholesale price that will be observed in equilibrium, respectively. The case of a prohibitive tariff allows us to highlight the fact that optimal prices are increasing with the number of integrated outlets.

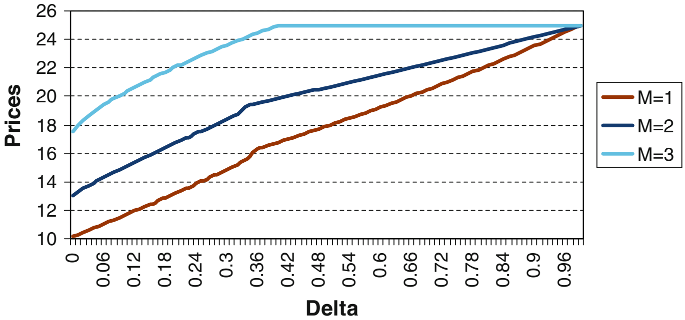


**Fig. 1** Final product prices, prohibitive tariff

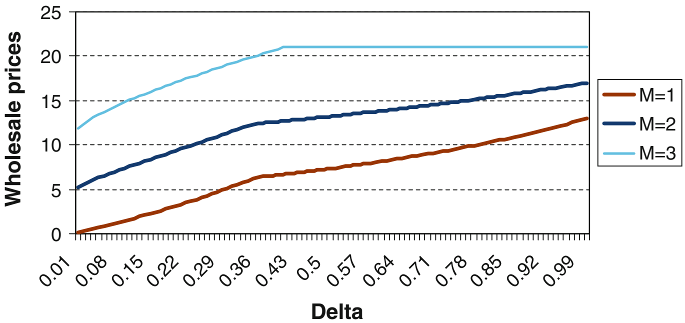


**Fig. 2** Posted wholesale prices, prohibitive tariff

Notice first that both output and wholesale prices are non-decreasing in the number of integrated outlets. It is also interesting to notice that when $M = N - 1$, i.e. when there is only one non-integrated outlet, it is optimal to set the price at the monopoly level, for a high enough discount factor, in this case $\delta \geq 0.41$. Indeed, the vertical structure would like to set the monopoly price for any value of the discount factor, although when $\delta$ is low, it is forced to set a lower price and to produce some output (to satisfy its own incentive constraint). When $M < N - 1$, notice that the optimal price equals the monopoly price only when $\delta = 1$. Hence, comparing these prices with those in the standard symmetric collusive arrangement in an $N$-firm oligopoly, we see that prices are indeed lower under vertical integration, at least for some range of values of the discount factor. Finally, the changes in slope that are observed in the pricing functions correspond to changes in the type of collusive arrangement chosen by the vertical structure. For instance, when $M = 2$, the vertical structure's constraint is binding for $\delta \leq 0.35$. Thus for $\delta > 0.35$, the solution is determined by $\widetilde{p}(\delta, N, M)$, as defined in (10), and the vertical structure does not produce in the optimal collusive arrangement.

The wholesale prices are also increasing with the discount factor and with the number of integrated outlets. When $\delta = 1$, they are set to leave non-integrated firms exactly with Cournot profits, provided that non-integrated firms produce the whole output, and the optimal price reaches the monopoly level. When $M = N - 1$, the wholesale price is constant at $w = 21$ for $\delta \geq 0.41$, to leave the non-integrated firm with Cournot profits.

### 5.2 The effect of tariffs on integration

So as to analyze the impact of tariff protection on the upstream firm's decision on whether to integrate forward and whether to service non-integrated firms, we consider three realizations of the tariff rate, namely, $T = 15$, 20, and 25. The rest of the relevant parameters take the same values as in the previous subsection.

First, Fig. 3 compares the net profits from vertical integration as a function of the discount factor, should the firm decide to integrate with one, two, or three downstream firms when $T = 15$. This represents the upper bound on the domestic price for the final product. In this case, when $\delta \geq 0.32$**,** the upstream firm decides to integrate with only one outlet, whereas it integrates with two outlets if the discount factor is below that level. Integration with three outlets is unprofitable due to the convex organizational costs, and also due to the existence of the tariff, which introduces an effective cap on the output price for a wider range of values of the discount factor.

Now, if $T = 20$, notice that the critical value of the discount factor above which integration with only one firm is optimal has increased to 0.75 (Fig. 4). Thus for values of the discount factor in the interval [0.32, 0.75], it is optimal to integrate with one

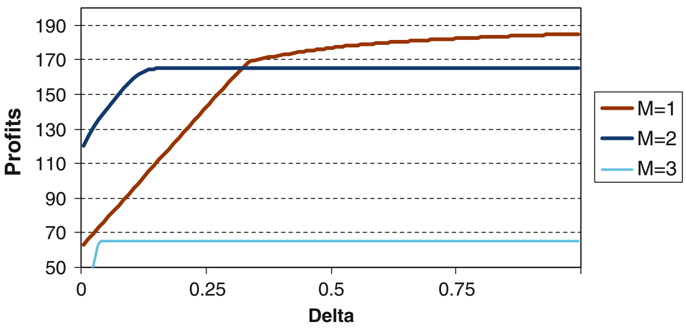


**Fig. 3** Profits, $T = 15$

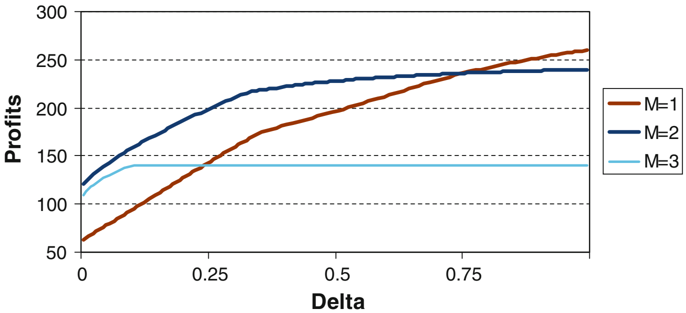


**Fig. 4** Profits, $T = 20$

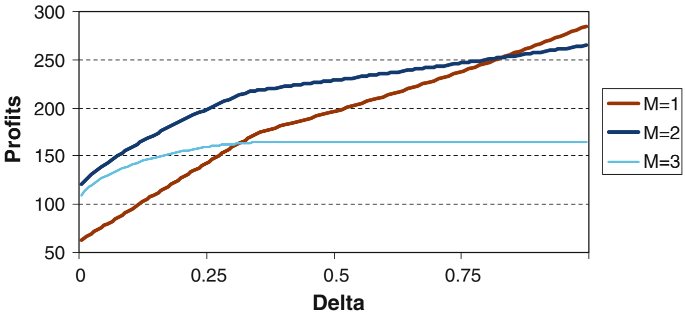


**Fig. 5** Profits, $T=25$

downstream firm if $T = 15$, but with two downstream firms if $T = 20$. Of course, this is due to the fact that a higher tariff relaxes the constraint on output prices for a wider range of values of the discount factor if $M = 2$ than if $M = 1$. Notice also that profits if $M = 3$ have increased relative to the previous case, although they are not the optimal choice for any value of the discount factor. Finally, Fig. 5 displays profits in the case of the minimum prohibitive tariff, $T = 25$. We observe that integration with only one downstream firm is optimal only if $\delta \geq 0.83$, a threshold value that has increased relative to the case $T = 20$. Note that collusion is always implemented in our model. Then when $\delta$ is higher than 0.83, it implies a collusive situation with prices close to monopoly. Interestingly, the integration decision of the vertical structure is not affected by the tariff for those values of $\delta$, that is, it will always integrate with one downstream firm.

All these numerical examples illustrate a positive relation between tariffs and forward integration: *higher tariff rates induce a higher degree of vertical integration*. Even without tariff protection on the intermediate product, the upper bound on its domestic price increases with tariff protection on the final product. Since the equilibrium price increases with the number of integrated outlets, raising the tariff rate on the final product increases the likelihood that the upstream monopolist finds it optimal to integrate with a larger number of downstream firms.

## 6 Concluding remarks

This paper has analyzed the impact of tariff protection downstream on the upstream monopolist's incentive to acquire downstream firms. The acquisition of additional outlets increases the vertical structure's profits, although it also increases its integration costs. In the presence of competitive imports, the effect of a tariff is to set an upper bound on the domestic price for the final good. By acquiring downstream firms the vertical structure is able to implement a collusive mechanism to non-integrated producers. Since it is found that optimal collusive prices are increasing in the discount factor as well as on the number outlets, raising tariffs makes it less likely that tariffs will impose a constraint on prices and profits from integrating with more downstream firms. This is the reason why there is a direct relationship between tariffs downstream and the number of downstream firms that an upstream monopolist is interested in acquiring. This theoretical result is consistent with the empirical findings in Alfaro et al. (2010). Furthermore, it is also proven that the optimal collusive price is typically below the monopoly price, which is in accordance with the evidence reported in Levenstein and Suslow (2006).

The literature on cartels has studied the role of cost asymmetries in limiting sustainability of collusion. However, this result relates to a collusive mechanism established among firms producing at the same stage in the production chain. The collusive mechanism we have studied takes place among firms at different stages. Consider then that the domestic upstream firm enjoys a cost advantage over foreign rivals. In that case, a deviating downstream firm would have to procure the input at the competitive worldwide price which would now be higher as compared with the cost symmetry case. Since the vertical structure profits are decreasing with the non-integrated firms profits and the latter are the deviating profits, we might conclude that, for any given tariff, a domestic cost advantage further facilitates vertical integration. The opposite would hold for a cost disadvantage. This is an important issue since a testable implication can be stated that relates upstream cost advantages and integration.

In our framework vertical integration has consequences on the input trade flows. Without integration, the domestic downstream firms will basically purchase the input in the world market. With integration, purchases substitute for imports of the input; the upstream domestic firm services the domestic market as a consequence of collusion. It is important to note that the logic of our paper remains valid had we assumed a foreign upstream firm integrating with domestic downstream firms. However, this would now imply no changes in trade flows as compared with non-integration.

## Appendix 1: Optimal deviation profits for non-integrated firms

Consider first, that a non-integrated downstream firm deviates by purchasing the input in the world market. We will refer to this deviation as $D1$. The vertical structure will, in the deviation period, respond optimally to the downstream firm's deviation, since it observes whether non-integrated firms have purchased any amount of inputs from it. If in the collusive outcome each of the $N-M-1$ non-integrated downstream firms produces $\alpha$, the deviating firm and each one of the $M$ integrated downstream firms optimally produce and make single-period profits of:

$$q_{D1}^{D}(\alpha, N, M) = \frac{(a - b(N-M-1)\alpha)}{b(2+M)}; \quad \pi_{D1}^{D}(\alpha, N, M) = b\left(q_{D1}^{D}\right)^{2},$$

which are profits for an $M+1$ oligopoly operating with zero marginal costs, taking as given the production of the $(N-M-1)$ non-integrated downstream firms that do not deviate. The subscript refers to the obvious notation. Notice that these profits are decreasing with $\alpha$.

Alternatively, a non-integrated downstream firm can deviate from the collusive outcome by acquiring $\alpha$ units of the input from the upstream firm at price $w > 0$, and then purchasing some additional units in the world market at zero price. We will refer to this deviation as $D2$. Recall that these additional purchases of input remain unobserved to the vertical structure and to the rest of the non-integrated firms. If each of the $N-M$ non-integrated firms produces $\alpha$, and hence the vertical structure, denoted by subscript $vs$, produces $q_{vs}(p,\alpha,N,M)=\frac{a-p}{b}-(N-M)\alpha$, then a non-integrated downstream firm's optimal deviation output and profits are given by:

$$q_{D2}^{D}(p,w,\alpha,N,M)=\frac{p+b\alpha}{2b};\quad \pi_{D2}^{D}(p,w,\alpha,N,M)=b\left(q_{D2}^{D}\right)^{2}-w\alpha,$$

Now, taking into account the fact that the vertical structure will always adjust the value of the wholesale price to make non-integrated firms' constraints binding, we may write

$$\pi_{D2}^{D}(p,\alpha,N,M)=\pi^{C}(N)+\frac{(p-b\alpha)^{2}}{4\delta b}$$

which means that single period deviation profits are:

$$\pi_{n}^{D}(p,\alpha,N,M)=\max\left\{\pi_{D1}^{D}(\alpha,N,M)=\frac{(a-b(N-M-1)\alpha)^{2}}{b(2+M)^{2}},\pi_{D2}^{D}(p,\alpha,N,M)\right.$$
$$\left.=\pi^{C}(N)+\frac{(p-b\alpha)^{2}}{4\delta b}\right\}.$$

We need to compare both deviation profits. In order to do so, notice that, assuming that the deviation occurs according to the second strategy, and that the vertical structure's incentive constraint is non-binding, the vertical structure's profits will be increasing with $\alpha$ as long as $\alpha\leq\frac{p}{b}$. Thus, the vertical structure has an interest in maximizing the non-integrated firms' share. However, it is also true that $\alpha$ cannot exceed the level $\frac{a-p}{b(N-M)}$, which is the level when the vertical structure does not produce at all. Thus, the vertical structure remains inactive whenever $p\geq\frac{a}{N-M+1}$.

If $p\geq\frac{a}{N-M+1}$ and hence $\alpha=\frac{a}{N-M+1}$, notice that

$$\pi_{D1}^{D}(p,N,M)=\frac{(a+p(N-M-1))^{2}}{b(M+2)^{2}(N-M)^{2}}\quad\text{and}$$
$$\pi_{D2}^{D}(p,N,M)=\pi^{C}(N)+\frac{(a+p(N-M+1))^{2}}{4\delta b(N-M)^{2}}$$

and it is easy to see that $\pi_{D2}^{D}(p,N,M)>\pi_{D1}^{D}(p,N,M)$. Similarly, if $p<\frac{a}{N-M+1}$ and hence $\alpha=\frac{p}{b}$,

$$\pi_{D1}^{D}(p,N,M)=\frac{(a-p(N-M-1))^{2}}{b(M+2)^{2}}\quad\text{and}\quad\pi_{D2}^{D}(p,N,M)=\pi^{C}(N)$$

and again, $\pi_{D2}^{D}(p,N,M)>\pi_{D1}^{D}(p,N,M)$. Therefore, $\pi_{n}^{D}(p,\alpha,N,M)=\pi_{D2}^{D}(p,N,M)$.

Whenever the vertical structure's incentive constraint is not satisfied, which occurs for low realizations of the discount factor, the relationship between $\alpha$ and $p$ is quadratic, which does not allow for the writing of a closed-form solution. In the numerical examples, it will be verified that the optimal deviation in all cases will be $D2$.

## Appendix 2: Optimal collusive price for low values of the discount factor

The vertical structure's incentive constraint imposes lower and upper bounds on $\widetilde{p} \in [p^-, p^+]$ for a sufficiently large discount factor. Let $p^-$ and $p^+$ be the roots of the following expression,

$$(N-M)\left(\frac{\delta(a+(N-M-1)p)^2-(a-(N-M+1)p)^2}{4b\delta(N-M)^2}-\pi^C\right)$$
$$=\frac{(1-\delta)}{\delta}\frac{p^2}{4b}+M\pi^C,$$

which is the saturated vertical structure's incentive constraint, under the assumption of non-integrated downstream firms producing the whole output. These bounds exist as long as $\delta$ is sufficiently large, $\delta > \hat{\delta}$, where $\hat{\delta}$ is the value of the discount factor that equals the discriminant of the above quadratic equation to zero. Note that $\hat{\delta} < \tilde{\delta}$, where $\tilde{\delta}$ is the value that equals $\tilde{p}(\tilde{\delta}) = p^+(\tilde{\delta})$, and $\tilde{\delta} \in (0, 1)$. Thus, the equilibrium price is $\tilde{p}$ for all $\delta > \tilde{\delta}$. In contrast, when $\delta < \tilde{\delta}$ the vertical structure cannot set the price equal to $\tilde{p}$ since it will not satisfy its incentive constraint. Thus, the vertical structure selects first $\alpha$ such that the vertical structure's incentive constraint is satisfied and next obtains the price that maximizes its profits.

We first compute the $\alpha$ that satisfies the vertical structure's incentive constraint, given an arbitrary price $p$:

$$p\left(\frac{a-p}{b}-(N-M)\,\alpha\right)+\delta\,(N-M)\left(\frac{\delta\left((p+b\alpha)^2-4b\pi^c\right)-(p-b\alpha)^2}{4b}\right)$$
$$=(1-\delta)\,\frac{(a-b\,(N-M)\,\alpha)^2}{4b}+\delta M\pi^C$$

The above expression is a quadratic convex polynomial in $\alpha$ with the following roots:

$$\alpha^{+,-}=\frac{a-p}{b(N-M+1)}$$
$$\pm\frac{\sqrt{(N-M)(1-\delta)[\delta(a-(N-M)p)^2-(a-(N-M+2)p)^2-4bN(N-M+1)\delta\pi^C]}}{b(N-M+1)(N-M)(1-\delta)}$$

Recall that the vertical structure's profits are increasing with $\alpha$ as long as $\alpha \leq \frac{p}{b}$. For this reason, if $\frac{p}{b} \in [\alpha^-, \alpha^+]$, it is the chosen value of $\alpha$. Otherwise, if $\frac{p}{b} > \alpha^+$, then $\alpha = \alpha^+$, and if $\frac{p}{b} < \alpha^-$, then $\alpha = \alpha^-$. However, it is true that the price will be below $\frac{a}{N-M+1}$, which implies that the chosen $\alpha$ will always be below $\frac{p}{b}$. To see this, notice that even if non-integrated firms were to produce the whole output, i.e. if $\alpha = \frac{a-p}{b(N-M)}$, this share is below $\frac{p}{b}$. Then, $\alpha = \alpha^+$and the vertical structure computes the $p$ that maximizes:

$$p\left(\frac{a-p}{b} - (N-M)\,\alpha^+\right) + (N{-}M)\left(\frac{\delta\left(\left(p+b\alpha^+\right)^2 - 4b\pi^c\right) - \left(p-b\alpha^+\right)^2}{4b\delta}\right)$$

We denote by $p'$ the argmax of the above expression which is implicitly defined by:

$$\left(1 - b\frac{\partial\alpha^+(p)}{\partial p}\right) = \frac{2\delta(a-2p)}{(1-\delta)(p-b\alpha^+(p))}$$

In the examples included in the text, the vertical structure's optimal behavior for $0 < \delta < \tilde{\delta}$ has been computed numerically, since no closed form solutions exist for this case. The price that maximizes the vertical structure's profits—and that, by construction, satisfies both incentives constraints—has been obtained for every value of the discount factor $\delta$.

## Appendix 3: Proof of Propositions 1 and 2

*Proof of Proposition 1* The collusive price $\widetilde{p}(\delta, N, M)$ is a non-decreasing function of $M$ and it falls into the $[\frac{a}{N-M+1}, p^m]$ interval. Now, if $p^C < T < \frac{a}{N-M+1}$, since $T < \widetilde{p}(\delta, N, M)$, the home industry is disciplined by the tariff for every value of the discount factor $\delta$. For these values of the tariff rate, the vertical structure produces a positive amount of the final product in equilibrium. Second, if $\frac{a}{N-M+1} < T < p^m$, there is a threshold value of the discount factor $\widetilde{\underline{\delta}}(N, M, T)$, which is implicitly defined by $\widetilde{p}(N, M, \delta) = T$ i.e. $\widetilde{\underline{\delta}}(N, M, T) = \frac{(N-M+1)(T(N-M+1)-a)}{(N-M-1)[T(N-M-1)+a]}$. This threshold value is increasing with $T$ and $N$ while decreasing with $M$. Therefore, if $\delta \in (0, \widetilde{\underline{\delta}}(N, M, T)]$ then the equilibrium price is $\widetilde{p}(N, M, \delta)$ while for $\delta \in \left(\widetilde{\underline{\delta}}(N, M, T), \underline{\delta}(N)\right)$ then the tariff disciplines the downstream home market and the observed price is $T$. □

*Proof of Proposition 2* Suppose that the discount factor is high enough so that the vertical structure's incentive constraint is non-binding given a price $\widehat{p} = \min\{\widetilde{p}, T\}$. Then, for any tariff $T < p^m$ we can establish an ordering of the minimum discount factors for which the tariff disciplines the behavior of the vertical structure, in the sense that $\widehat{p} = \min\{\widetilde{p}, T\} = T$. In particular,

$$0 = \widetilde{\underline{\delta}}(N, N, T) \leq \widetilde{\underline{\delta}}(N, N-1, T) \leq \widetilde{\underline{\delta}}(N, N-2, T) \leq \cdots \leq \widetilde{\underline{\delta}}(N, 1, T)$$

i.e. it is more likely that the tariff disciplines the vertical structure's optimal behavior the greater the number of integrated downstream firms.

Now, if the tariff increases to, say $T' > T$, for every $M$ the price—and profits —increases for $\delta > \underset{\sim}{\delta}(N, M, T)$. Given the above ordering, the range of values for which prices and profits increase after the tariff is raised decreases with $M$. In particular, for every $M$, there is an interval $[\underset{\sim}{\delta}(N, M, T), \underset{\sim}{\delta}(N, M-1, T)]$ for which profits increase if the number of integrated outlets is $M$, but not if it is $M-1$. For $\delta > \underset{\sim}{\delta}(N, M-1, T)$, profits increase both for $M-1$ and $M$, but more in the latter case because $\frac{\partial \pi_{vs}}{\partial \widehat{p}}$ increases in $M$. To see this, notice that there are two possible expressions for $\pi_{vs}$. If the vertical structure does not produce at all, the price will be given by $\widehat{p} = T$ and each non-integrated firm will produce $\alpha = \frac{a-\widehat{p}}{b(N-M)}$. In this case, the expression for $\frac{\partial \pi_{vs}}{\partial \widehat{p}}$ is

$$\frac{\partial \pi_{vs}}{\partial \widehat{p}} = \frac{(N-M)(a-2\widehat{p})}{b\delta} - \frac{(1-\delta)(N-M-1)}{2b\delta}(a + p(N-M-1))$$

which is increasing with $M$. The other possibility is that the vertical structure produces a positive amount of the final good, and thus $\alpha = \frac{\widehat{p}}{b}$, which occurs whenever $\widehat{p} < \frac{a}{N-M+1}$. For instance, this is the case if $M = N-1$ and the tariff $T$ is non-prohibitive. In this case, the expression for the partial derivative is

$$\frac{\partial \pi_{vs}}{\partial \widehat{p}} = \frac{(N-M)(a-2\widehat{p})}{b\delta}$$

which turns out to be always greater than the previous expression. Hence, whenever the tariff constraints the vertical structure's pricing strategy, a tariff raise benefits the vertical structure more the greater the number of integrated firms. □



## References

Alfaro L, Conconi P, Fadinger H, Newman AF (2010) Trade Policy and Firm Boundaries. NBER Working Paper No. 16118

Bond EW, Syropoulos C (2005) Is the Tariff the "Mother of Trusts"? Reciprocal Trade Liberalization with Multimarket Collusion. Vanderbilt University mimeo, Nashville

Chemla G (2003) Downstream competition, foreclosure, and vertical integration. J Econ Manag Strategy 12:261–289

Davidson C (1984) Cartel stability and tariff policy. J Int Econ 17:219–237

Feuerstein S (2005) Collusion in industrial economics—a survey. J Ind Compet Trade 5(3):163–198

Friedman JW (1971) A non-cooperative equilibrium for supergames. Rev Econ Stud 38:1–12

Fung K-C (1987) Industry structure, antitrust and tariffs. Int J Ind Org 5:447–456

Hanson GH, Mataloni RJ, Slaughter MJ (2005) Vertical production networks in multinational firms. Rev Econ Stat 87(4):664–678

Lamoreaux N (1985) The great merger movement in American history, 1895–1904. Cambridge University Press, New York

Levenstein M, Suslow V (2004) Contemporary international cartels and developing countries: economic effects and implications for competition policy. Antitrust Law J 71(3):801–852

Levenstein M, Suslow V (2006) What determines cartel success? J Econ Literature XLIV (March 2006): 43–95

Mendi P (2009) Backward integration and collusion in a Duopoly model with asymmetric costs. J Econ 96(2):95–112

Mendi P, Veszteg R (2009) Sustainability of collusion: evidence from the 19th century basque iron and steel industry. Invest Econ 33(3):385–405

Nocke V, White L (2007) Do vertical mergers facilitate upstream collusion? Amer Econ Rev 97(4): 1321–1339

Ornelas E, Turner JL (2008) Trade liberalization, outsourcing, and the hold-up problem. J Int Econ 74:225–241

Spencer B, Jones R (1991) Vertical foreclosure and international trade policy. Rev Econ Stud 58(1): 153–170

Spencer B, Jones R (1992) Trade and protection in vertically related markets. J Int Econ 32:31–55

Webb S (1980) Tariffs, cartels, technology, and growth in the German steel industry, 1879 to 1914. J Econ Hist 40(2):309–330